APPLICATION

FOR

UNITED STATES LETTERS PATENT

To all whom it may concern:

Be it known that I, Nonda Katopodis

have invented certain new and useful improvements in

METHOD FOR DETERMINING LIPID ASSOCIATED SIALOPROTEIN IN BODY FLUIDS

of which the following is a full, clear and exact description

BACKGROUND OF THE INVENTION

This invention pertains to a method of identifying patients with brain tumors and to determine the response of patients to treatment. The method of the invention can distinguish patients with malignant primary and metastatic brain tumors by measuring the increase of lipid associated sialoprotein (LSP) in the cerebrospinal fluid (CSF). The invention also can determine the response to treatment and therefore it can be used to monitor radiation and chemotherapy.

There exist other methods and procedures for distinguishing patients with malignant brain tumors from benign tumors. However, these methods typically require tumor tissue which is not practical on a routine basis or sophisticated equipment such as MRI spectroscopy which is expensive and not widely available. On the other hand, CSF is easily and safely accessible in nearly all patients and can be examined at reasonably frequent intervals without comprising a patient's safety. Moreover, MRI scanning is frequently unrevealing or equivocal with respect to early indications of central nervous system attack by systemic tumor metastasis.

The method of the invention whereby LSP is measured in the CSF has been shown to provide an early indicator of central nervous system involvement. Prior to the method of the invention there has been no specific tumor marker for brain cancer. Moreover, the method of the invention is extremely cost

effective, particularly when compared with the significant cost associated with an MRI examination.

More than one hundred thousand new cases of brain tumors were diagnosed in 1998. By the time the symptoms appear most tumors have infiltrated widely and surgery, cranial irradiations and chemotherapy can provide only questionable benefit. Diagnosis of brain tumors generally occur after the onset of neurologic manifestations. By that time the tumor is well established and for the vast majority of patients this is fatal. Modern neuroimaging techniques such as magnetic resonance imaging (MRI), spectroscopy, and position emission tomography have facilitated early diagnosis. However, these studies are expensive and cumbersome and are limited by false negative and false positive findings in a number of common situations including radiation necrosis, central nervous system infections, or vascular malformations. A convenient, reliable and efficient screening test which can detect brain metastases at an early stage to initiate treatment in patients at high risk has not been currently available. Also lacking is a reliable method to detect tumor reoccurrence, predict response to therapy, and distinguish between persistent or recurrent tumor and treatment related changes in patients with primary brain tumors.

A number of antigens have been suggested as tumor serologic markers. For example, there are squamous cell carcinoma antigen, prostate specific antigen, carcinoma embryonic antigen, and

antigens labeled CA 125 for ovarian cancer, CA 153 for breast cancer and CA 19-9 for pancreatic cancer. These markers are serologic markers identified in the blood for systemic tumors but no such markers have been found in the blood of patients with primary brain tumors. Most brain tumor markers reflect chromosomal abnormalities such as gene mutations, translocations, and fibroblasts growth factor expression. However, these markers are determined only when biopsy specimens are obtained and the tumors themselves are analyzed. They are not useful as diagnostic aids or to assess a response to ongoing therapy.

The method of the invention makes use of cerebro spinal fluid (CSF) as a source of biological indicators that can provide information regarding the presence of a tumor in the CSF and its status. The method of the invention shows that CSF contains specific markers which provide a basis for evaluating the presence of a tumor in the CSF or its activity.

It has long been known that tumor cells have caused changes in the metabolism of sialic acid. These changes result in larger amounts of sialic acid being present on the surface of malignant tumor cells compared to benign tumor cells.

It was suggested that Sialic Acid (S.A.) might be a useful tumor marker 25 years ago when a new protein lipid complex was identified in rats with Walker adenocarcinoma. In 1977 Kloppel and his collaborators for the first time used serum S.A. as a marker for cancer. The most commonly used method is one

developed by Katopodis e. al. LSA has been found to be more reliable than other markers in identifying patients with head and neck cancer, localized and metastatic prostate cancer, lung cancer, leukemia, lymphoma, Hodgkins' lymphoma, melanoma and others.

These serologic markers of the prior art are principally identified in the blood for systemic tumors. The method of the invention makes use of the CSF and has determined that material produced by the tumor or the surrounding cells in response to the tumor are diffused into the CSF.

SUMMARY OF THE INVENTION

The present invention provides a method to determine the levels of lipid associated sialoprotein (LSP) in the cerebrospinal fluid (CSF) which includes the following steps:

a) obtaining a CSF sample in the amount of 500ul. No dilution is necessary because the sample by its nature is very diluted. This fact also dictates that a larger sample is required.

b) adding to the sample mixture of a chlorinated lower alkyl hydrocarbon and a lower alkyl alcohol, the volume and ratio of chlorinated hydrocarbon to alcohol in the mixture being approximately 2 to 1;

c. centrifuging to obtain a clear upper phase;

d. extracting the upper phase resulting from said mixing;

e. treating predetermined amounts of said upper phase with a protein precipitating agent having a predetermined concentration;

f. centrifuging the admixture for a suitable period of time and washing the precipitate with saline solution in a predetermined amount;

g. centrifuging the resulting admixture for a suitable period of time;

h. dissolving the precipitate in a buffer solution;

i. treating the mixture with a hydrolysis agent;

j. heating the resulting mixture at a predetermined temperature for a predetermined time; and

k. determining the amount of lipid associated sialoprotein in the suspended precipitate and thereby the amount present in the CSF sample.

The determination of the amount of lipid associated sialoprotein in the sample is made by comparing the optical density of the sample to that of a known concentration of standard.

The method of the invention provides a reliable test to distinguish between malignant brain tumors and benign brain tumors. The invention also provides a method for monitoring a patient's response to treatment.

DETAILED DESCRIPTION OF THE INVENTION

The amount of LSP in a sample of CSF may be determined and the amount determined used as a diagnostic indicator of brain tumors. A preliminary step to the method is to obtain a sample to be tested. A sample will typically be recovered by means of lumbar puncture whereby CSF is easily and safely accessible in nearly all patients and can be examined at reasonably frequent intervals without compromising the patient's safety.

The initial amount of the CSF sample must be in the amount of 500ul. The present invention eliminates the need for diluting as in the prior art because the LSP is highly diluted in CSF. It is this high dilution that requires a larger sample of CSF than of the samples of the prior art.

The sample is then treated with a mixture of a chlorinated lower alkyl hydrocarbon and a alkyl alcohol in which the volume ratio of chlorinated hydrocarbon to alcohol is about 2 to 1. The volume of the hydrocarbon alcohol mixture added to the sample is approximately 750ul which is a much smaller volume than the prior art because of the elimination of the dilution step in the prior art. Water or buffer for partitioning is not added as in the prior art since contaminants will dissolve from the interface to the upper phase. Contaminants are other soluble proteins and glycoproteins, also pigments from hemoglobin from hemolysed blood (resulting from injury during CSF collection) which will increase the final color in reaction with the resorcinol agent. Suitable

chlorinated hydrocarbons include chloroform, methylene chloride and ethylene chloride, chloroform being presently preferred. The lower alkyl may be methanol, ethanol, propanol, n-butanol or the like.

The resulting admixture is then centrifuged at 3500 rpm for 5 minutes to obtain a substantially clear upper phase.

The predetermined volume of the upper phase is then separately recovered from the substantially clear upper phase so formed in a volume that was predetermined by the volume of the original CSF sample. If the original volume of the pre-determined CSF sample is 500ul, the volume of the upper phase separately recovered will be 500ul.

This predetermined volume of the upper phase is then treated with the protein precipitating agent such as aqueous phosphotungstic acid solution in a concentration in the range of 0.3 to 0.6 milligrams per milliliter. The amount of the protein precipitating agent (PTA) in the solution is far more diluted than the one used in the prior art. This low concentration of PTA is selectively precipitating the LSP because this concentration of PTA affects the isoelectric point of the protein existing in the LSP complex. Higher concentrations of PTA as in the prior art would coprecipitate still existing contaminants in the upper phase such as other proteins and glycoproteins present in CSF thus producing a contaminated precipitate and adversely affecting the results of the method of the invention. On the

other hand a concentration lower than .03 mg/ml would not be enough to precipitate quantitatively the LSP.

The resulting admixture is centrifuged between 1,000 and 1,100 rpm for 5 minutes to produce a resulting precipitate. A lower rpm does not complete the precipitation while a higher rpm makes the precipitate solid so that only part of the precipitate is exposed to washing with saline solution and thus not all of the contaminants are removed. The supernatant is decanted and the remaining precipitate is washed with 500ul of saline solution to remove any traces of contaminants. It is essential that saline solution and not water be used to wash the precipitate as the saline solution is effective in removing the contaminants which have been precipitated as a result of the isoelectric precipitation of the protein of the LSP as described above. The resulting admixture is then centrifuged at 3500 rpm for 5 minutes to form a clear precipitate. The supernatant again is decanted. The resulting precipitate is then dissolved in 200 microliters of distilled water.

The resulting admixture is then hydrolized with resorcinol reagent in a heating block at a temperature between 115 to 120 degrees centigrade over a period of 15 minutes. It is important that the temperature be increased to 120 degrees during this heating step in order to complete the hydrolysis of the LSP complex and to completely destroy the remaining contaminants after purification and washing. Maintaining the temperature in

this narrow range is essential to the method of the invention because at a lower temperature the hydrolysis will be incomplete (less color and less accuracy) while at a higher temperature the hydrolized components of the complex will turn to a dark brown color interfering with the blue color measured at 580 nm as described below.

The mixture is then treated with a mixture of butyl acetate and n-butanol in a ratio of 85 to 15 by volume and then treated by mixing, centrifuging, separating the organic layer, reading at 580mm the extracted blue color present in the organic layer and determining the amount of LSP in the sample by comparing the optical density of the sample with the standard curve developed by a standard sample of n-acetyl neuraminic acid.

The reliability and accuracy of the present invention can be seen from the following graphs.

FIG. 1 shows the concentration of LSP in the CSF patients with and without brain tumors. It can be seen that the concentration of LSP is significantly higher in patients with malignant primary brain tumors and metastatic brain tumors as compared to those with benign primary brain tumors, systemic malignant tumors without brain metastasis, and neurologic controls (dizziness, headaches, strokes, lyme disease, alzheimers and HIV). FIG. 2 shows the correlation of LSP in longitudinal studies of patients with brain tumors under radiation and chemotherapy. FIG. 3 shows the significantly increased

concentration of LSP in the CSF of patients with malignant primary brain tumors and a much lower concentration in patients with benign primary brain tumors. FIG. 4 compares the increased concentration of LSP in the CSF of patients with metastatic brain tumors versus patients who do not have metastatic brain tumors. FIG. 5 shows the higher concentration of LSP in the CSF of patients with lymphoma and a much lower concentration in patients with HIV and toxoplasmosis. FIG. 6 charts the concentration of LSP in the CSF of control samples (dizziness, headaches, strokes and the like), of neurological samples (lyme disease, Alzheimer's, Meningitis) and of samples from patients having malignancies in different stages.